Data Quality Objectives for Great Salt Lake Project 2B: Synoptic Survey of Selenium in Water, Seston, and *Artemia*

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<tr><th>Step</th><th>DQO Guidance of Purpose and Outputs of Step</th><th>Great Salt Lake Project</th></tr>
<tr><td>1. Problem Statement</td><td> Purpose: Clearly define the problem that requires new environmental data so that the focus of the study will be clear and unambiguous. Outputs From This Step A concise description of the problem.
A list of the planning team members and identification of the decision maker.
A summary of available resources and relevant deadlines for the study.</td><td> Problem: The State of Utah, Department of Environmental Quality, Division of Water Quality and North Davis County Sewer District need additional critical information for the establishment of a defensible site-specific standard (SSS) for selenium in the open waters of the Great Salt Lake (GSL). Essential components of the SSS have been identified in a detailed conceptual model of selenium cycling in the GSL (Bill Johnson et al., CWECS, University of Utah). This task specifically addresses trophic transfer of selenium within food webs from water to particulate matter (seston) to the dominant zooplankton species Artemia franciscana. With respect to the conceptual model these linkages reflect the following pathways: Water column (excluding deep brine layer) selenium to seston (particulates including phytoplankton): Pathway 39
Seston to Artemia: Pathways 17 and 18
Artemia to avian predators: Pathways 11, 12, and 13. Information from this task will complement avian studies as set forth in Project 1, as well as selenium loading research defined in Project 3. The following high-priority questions will be addressed by this task: What are the concentrations of selenium in GSL water, seston, and Artemia tissue?
a) What is the correlation between waterborne concentrations of selenium and levels found in seston and Artemia?
b) What is the potential dietary selenium risk to avian species from consuming Artemia?
What are the temporal and spatial patterns of isotopic carbon (^{13}C) and nitrogen (^{15}N) in particulate organic matter (POM) and Artemia tissue?
a) Do ^{13}C and ^{15}N correlate with selenium concentrations in POM and Artemia?
b) Do selenium, ^{13}C, and ^{15}N in Artemia correlate with seston (i.e., phytoplankton abundance)?
c) Do the stable isotope fractions in diet indicate discrete sources of selenium that account for Artemia tissue levels of selenium? Do the sources supporting the Artemia body-burdens of selenium vary seasonally?
What are the population size, age-structure, and biomass of Artemia in the GSL?
a) What is the total selenium load in the GSL Artemia population?
b) How do changing Artemia tissue concentrations of selenium and the abundance of adults or cysts correlate with avian consumers and avian seasonality and nesting at GSL? Planning team members: Brad Marden (Principal Investigator), Dr. Earl Byron (Project Advisor), with ultimate decision authority by Utah Department of Environmental Quality, considering input by the GSL Steering Committee and GSL Science Panel. Resources: Estimated budget for sampling year 2006 is $124,100, including lab costs. Vessels, vehicles, and laboratory facilities necessary for sample collection, preparation, and Artemia enumeration will be made available through an agreement with the Utah Strategic Alliance (USA), Mountain Green, UT (MtG). USA is an alliance of brine shrimp industry members. They have a dedicated research vessel that will be provided for the sampling component of this project. The USA will also make available its Artemia laboratory facility in MtG. A laboratory analyst, field sampling assistant, and mechanic will also be provided by the USA for this project. Technical support for water and particulate sampling and analysis will be available through Dr. Bill Johnson at the University of Utah, Dr. Dave Naftz at the USGS and Dr. Earl Byron at CH2M HILL. Deadlines: April 21, 2006: SOPs, QA/QC protocols, equipment acquisition and testing, sampling methodology, sample site verification.
April 30, 2006: first sampling program.
May 1 through November 30, 2006: Monthly or semi-monthly sampling programs and bi-monthly reports.
August 31, 2006: 6-month summary
January 31, 2007: Final Report </td></tr>
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2. Decision Statements	**Purpose**: Define the decision(s) that will be resolved using data to address the problem. **Approach**: Identify the key question that the study attempts to address and alternative actions that may be taken, depending on the answer to the key study question. **Outputs From This Step** • A statement of the decision that must be resolved using data in order to address or solve the problem. • A list of possible actions or outcomes that would result from each resolution of the decision statement. *Note from EPA guidance on DQO: If the principal study question is not obvious and specific alternative actions cannot be identified, then the study may fall in the category of exploratory research, in which case this particular step of the DQO Process may not be needed.*	**Decisions:** • Results will be used to support an interim selenium standard for the GSL that is protective of wildlife species. More specifically, trophic transfer of selenium within the food web, and bioaccumulation factors from water to seston to *Artemia*, can be used to define a waterborne concentration of selenium that serves to keep the aquatic organism/prey-base tissue value within an adequately protective range for waterfowl and shorebirds. **Possible outcomes:** 1. Determination of an interim water quality standard for the GSL that is partially based upon trophic transfer statistics, and bioaccumulation factors, and can be used for discharge permitting procedures and watershed management decisions. 2. Artemia tissue selenium concentration that is equal to, or below, the acceptable risk level for aquatic-dependent birds: no immediate need for management action. Alternative: Artemia tissue concentration is above acceptable risk level and management action is necessary. 3. Artemia cyst selenium concentration that is equal to, or below, the acceptable risk level for aquatic-dependent birds: no management action becomes necessary. Alternative: Artemia cyst selenium concentration is above acceptable risk level and management action is necessary. 4. Prudent GSL watershed management decisions are made based upon an understanding of selenium cycling dynamics and isotopic nutrient assessments within three components of the GSL food web during an eight-month period.
3. Inputs to the Decision	**Purpose**: The purpose of this step is to identify the informational inputs that will be required to resolve the decision, and to determine which inputs require environmental measurements. **Activities** • Identify the information that will be required to resolve the decision. • Determine the sources for each item of information identified. • Identify the information that is needed to establish the action level for the study. • Confirm that appropriate field sampling techniques and analytical methods exist to provide the necessary data. **Outputs From This Step** • A list of informational inputs (including sources and potential action levels) needed to resolve the decision. • The list of environmental variables or characteristics that will be measured.	**Informational inputs:** Selenium concentrations in pelagic food web components: water, particulates, *Artemia* tissue, and *Artemia* cysts. ^{13}C and ^{15}N in particulates, *Artemia* tissues, and *Artemia* cysts. *Artemia* population dynamics. **Variables/characteristics to be measured:** • Zooplankton assessment: Artemia population characteristics (e.g., biomass, abundance, age-structure); cyst abundance and characteristics. • Total selenium concentrations: Artemia tissue, Artemia cysts, dissolved selenium in water column, selenium burden in particulate phase in water column. • Isotopic nutrients: ^{13}C and ^{15}N in Artemia tissue and POM. • Abiotic assessments: Secchi disk depth, dissolved oxygen, chlorophyll A, temperature.

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4. Study Boundaries	**Purpose**: Specify the spatial and temporal circumstances that are covered by the decision. **Activities** • Define the domain or geographic area within which all decisions must apply. • Specify the characteristics that define the population of interest. • When appropriate, divide the population into strata that have relatively homogeneous characteristics. • Define the scale of decision making. • Determine when to collect data. • Determine the time frame to which the study data apply. • Identify any practical constraints on data collection. **Outputs From This Step** • Characteristics that define the domain of the study. • A detailed description of the spatial and temporal boundaries of the decision. • A list of any practical constraints that may interfere with the study.	**Spatial:** • GSL pelagic zone. • Samples taken throughout water column. • Three regions of lake: North (Antelope Island/Ogden Bay entrance in Gilbert Bay); Central (Hat Island); and South (southern end of Gilbert Bay). • Three depth/substrate profiles with each sampling region: 1) Shallow/Stromatolite; 2) Medium/Sandy; 3) Deep/Unconsolidated and deep brine layer. **Temporal:** Sampling frequency: • Monthly: April, August, September, October, November • Semi-Monthly: May, June, July **Practical constraints on data collection:** • Inclement weather. • Equipment malfunction and failure. • Brine shrimp industry cooperation (i.e., equipment, vessel, facility, and staff from Utah Strategic Alliance)
5. Decision Rules	**Purpose**: The purpose of this step is to integrate the outputs from previous steps into a single statement that describes the logical basis for choosing among alternative actions. **Activities** • Specify the parameter that characterizes the population of interest. • Specify the action level for the study. • Combine the outputs of the previous DQO steps into an "if...then..." decision rule that defines the conditions that would cause the decision maker to choose among alternative actions. **Outputs From This Step** • An "if...then..." statement that defines the conditions that would cause the decision maker to choose among alternative courses of action.	If *Artemia* tissue and cyst selenium concentrations are at acceptable dietary levels for aquatic-dependent wildlife (currently proposed to be 5 mg/kg dry weight), then no management actions are necessary and SSS can be based on current conditions. If *Artemia* tissue and cyst selenium concentrations are relatively consistent both temporally and spatially, then distribution and bioavailability of selenium in the open water of the GSL will be considered uniform. Alternative: If there is a strong spatial or temporal component, then further analysis or study may be necessary to determine predominant factors influencing selenium tissue concentrations. If there is bioaccumulation of selenium through trophic levels, then bioaccumulation factors or regression relationships will be used to calculate a selenium water standard that is protective for aquatic-dependent wildlife. If there is a correlation among ^{13}C, ^{15}N, and selenium in *Artemia* tissue, then isotopic nutrient profiles may be used to prioritize inflow sources or food items for further investigation or water management decisions.

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6. Tolerable Limits on Decision Rules	**Purpose**: Specify the decision maker's acceptable limits on decision errors, which are used to establish appropriate performance goals for limiting uncertainty in the data. **Activities** • Determine the possible range of the parameter of interest. • Define both types of decision errors and identify the potential consequences of each. • Specify a range of possible parameter values where the consequences of decision errors are relatively minor (gray region). • Assign probability values to points above and below the action level that reflect the acceptable possibility for the occurrence of decision errors. • Check the limits on decision errors to ensure that they accurately reflect the decision maker's concern about the relative consequences for each type of decision error. **Outputs From This Step** • The decision maker's acceptable decision error rates based on a consideration of the consequences of making an incorrect decision.	*Artemia* tissue concentrations below 3 mg Se/kg are within a range that is considered representative of background conditions for many kinds of invertebrates and is anticipated to be "relatively safe" from decision errors and also for bird diets. However, further details are needed from Project 1 (avian dietary contents) to determine likely consumption amounts of *Artemia* by GSL birds. A range of 4 to 5 mg Se/kg is considered to represent a dietary threshold level for possible adverse effects, so measurements in that range are more critical. Tissue concentrations exceeding 5.0 mg Se/kg also are more susceptible to decision errors that may adversely affect wildlife if made incorrectly. Because of the judgmental nature of the sampling approach used in this study, no acceptable limits for decision error rates were determined for the sampling design. Specifications of tolerable limits on decision errors through the use of standard statistical methods are not applicable for these parameters. Data quality may also be specified under Measurement Quality Objectives. This quality assessment typically involves specifying performance criteria in terms of the precision, accuracy, representativeness, completeness, and comparability of the data. These performance criteria provide a measure of how well the established Measurement Quality Objectives were met. For this investigation, Measurement Quality Objectives for chemical measurements will be specified in the Quality Assurance Project Plan (QAPP); in general, the Measurement Quality Objectives for selenium are about +/- 20% and for non-selenium measurements they are +/-10%. The QAPP will specify all QA/QC objectives for sample measurement based on each matrix and may be more restrictive or less restrictive than +/-20%.
7. Optimization of the Sampling Design	**Purpose**: Identify the most resource-effective sampling and analysis design for generating data that are expected to satisfy the DQOs. **Activities** • Review the DQO outputs and existing environmental data. • Translate the information from the DQOs into a statistical hypothesis. • Develop general sampling and analysis design alternatives. • For each design alternative, formulate the mathematical expressions needed to solve the design problems. • For each design alternative, select the optimal sample size that satisfies the DQOs. • Select the most resource-effective design that satisfies all of the DQOs. • Document the operational details and theoretical assumptions of the selected design in the Sampling and Analysis Plan. **Outputs From This Step** • The most resource-effective design for the study that is expected to achieve the DQOs, selected from a group of alternative designs generated during this step.	Site Designation: Geographic regions have been designated to represent distinct and diverse input sources of surface water into the GSL. The North-Antelope Island region is strongly influenced by inflow from Farmington Bay and Ogden Bay and to a lesser extent the Bear River drainage. The Hat Island region is distant from any known surface flow input into the GSL. The South-end region is influenced by surface inflow from the Goggin Drain, Jordan River overflow canal, industrial discharges (e.g., Kennecott), and surface flows from Tooele Valley. These regions were assigned to provide a suitable cross representation of the GSL/Gilbert Bay hydrological system. Within each region, depth and substrate profiles were selected due to probable influences of temperature, light penetration, microalgal communities, and geochemical cycling factors. Sample pooling will be used to improve sampling accuracy of site conditions without increasing sample number. **Sample Size.** Sample size was determined to a large extent by logistical and financial constraints. Power analysis can be used to determine optimal sample size and to define alternatives for sample program modifications or subsequent years of research. **Hypotheses:** • Selenium bioaccumulates upward via trophic transfer mechanisms (though not necessarily increasing at each higher trophic level). • There is a correlation between waterborne selenium concentration and levels measured in seston, Artemia tissue and cysts. • There is a correlation between 13C, 15N, and selenium in Artemia tissue and POM. • Artemia population size and age structure are correlated with direct and indirect measures of zooplankton food availability (seston/phytoplankton and Chlorophyll A). • Artemia selenium tissue concentration is correlated with food availability.